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# An Analysis of Local Honey: Foraging Effects and Colony Fitness of Philadelphia (*Apis Mellifera* L.)

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An independent study project report by The Eli Kirk Price Endowed Flora of Pennsylvania Intern (2011-2012)

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Pollen, the primary dietary source of proteins, lipids, vitamins, and minerals, is essential to the physiological development of adult honey bees (*Apis mellifera* L.). A varied pollen diet is vital to immune system maintenance, organ development, and colony succession via brood production. The reasons for the recent decline in honey bee populations are wide-ranging but include a lack of diverse nectar and pollen resources. Resource deficiency and colony fitness is well understood within natural and agricultural landscapes; few studies have determined the importance of a polyfloral diet for bees existing in areas of intense development. Focusing on honey bees in the city of Philadelphia, we investigated the range of plants utilized as pollen sources and if there are significant colony-level benefits to foraging diversity. We examined the pollen content of honey samples collected from 15 Philadelphia hives from August to November 2011. Late season fitness of colonies was assessed by measuring hive-area covered by brood found in sampled hives. The findings presented here shed light on taxa visited by honey bees in an urban ecosystem. Identification and selection of plants shown to be principal pollen sources can be used to promote effective pollinator restoration programs in developing cities.

**Disciplines**
Botany | Horticulture

**Comments**
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## INTRODUCTION

In most ecosystems bees (Hymenoptera: Apiformes) are the primary pollinators of flowering plants (Buchmann and Nabhan 1996, Kearns et al. 1998, Aizen & Feinsinger 2003, Ashman et al. 2004). Of particular social interest is the reliance of fruit, seed, and nut crops on apiformes, particularly managed honey bee (*Apis mellifera* L.) populations (Klein et al. 2007). Estimates place the annual global value of pollination services, including those of wild and managed bees, at $216 billion per year, or 9.5% of the worldwide annual crop value (Gallai et al. 2009). Of course these fruits of labor do not go unrewarded. Reciprocally, from flowering plants bees derive all nutritional elements necessary for survival, growth, and reproduction.

For the adult honey bee, carbohydrates derived from nectar meet the daily cost of flying and foraging. An adult worker needs approximately 4 mg of utilizable sugar per day for survival (Barker & Lehner 1974). While nectar satisfies quotidian energetic requirements, the long term growth and reproduction of the honey bee colony is dependent on pollen intake. As the only natural protein source for honey bees, pollen is necessary for brood and young worker development. To rear one larvae 25-37.5 mg protein are needed (Hrassnigg and Crailsheim 2005) and colonies of about 50,000 individuals typically have an annual pollen budget of 20 kg (Seeley 1995). Within the hive, foraged pollen is mixed with regurgitated nectar and glandular secretions to produce brood food, a substance of high protein value that is fed to developing larvae. Other pollen-derived nutrients include lipids, amino acids, starch, sterols, vitamins, and minerals (Roulston and Crane 2000). The nutritive importance of pollen makes it one of the primary factors influencing colony longevity. For the non-reproducing worker caste of social insects, colony growth and reproduction through increased brood rearing are the principal sources of fitness (Sagili & Pankiw 2007). Colonies without pollen supply maintain brood rearing for a limited time. During an extreme pollen dearth, bees will attempt to supply the protein demand of brood first by depleting pollen reserves and then by cannibalizing other brood. By some accounts colonies will terminate brood rearing rather than produce malnourished larvae (Imdorf et al. 1998).

Colony malnutrition may also arise from constrained foraging diversity. No other chemical constituent of pollen influences as many aspects of bee nutrition as protein. Nonetheless, not all pollen is created equally and protein concentrations range from 2.5%-61% depending on the floral source (Roulston et al. 2000). Studies cite that the reasons for recent honey bee losses include a lack of diverse nectar and pollen resources, especially within intensively farmed agricultural landscapes (Kearns et al. 1998, Winfree et al. 2007, DeCourtye et al. 2010). Naug 2009 points out that current colony declines might simply be the breaking point where nutritional stress due to habitat loss and/or homogenization is significantly contributing to the synergistic effect of numerous other stressors being experienced by bees.

For example, deficient nutrition can impair immune function and increase honey bee colonies' susceptibility to disease. Alaux et al. 2011 tested whether dietary protein quantity (monofloral pollen diets of varying protein concentrations) and diet diversity (polyfloral pollen diets) influenced the immunocompetence of honey bees raised *in situ*. They found that polyfloral diets induced higher levels of glucose oxidase, a hypopharengeal gland enzyme that enables bees to sterilize brood food. Their results show that diversity in floral resources confers increased hive antiseptic protection. In addition to impaired immune response, non-diverse pollen diets can

affect the development of young brood. Honey bees require ten amino acids for development: arginine, histidine, lysine, tryptophane, phenylalanine, methionine, threonine, leucine, isoleucine and valine (De Groot 1953). Dandelion (*Taraxacum officianale*) pollen lacks tryptophane and phenylanine and is deficient in arginine. Honey bees raised solely on *T. officinale* pollen will fail to rear brood (Herbert et al. 1970), but supplementation of L-tryptophane L-phenylanine and L-arginine restored brood rearing (Herbert 1992).

The importance of polyfloral foraging (polylecty) for honey bee development and survival draws a distinct connection between habitat heterogeneity and colony fitness. Human disturbance, particularly the loss of natural and semi-natural habitats, is regarded as a primary cause of pollinator decline (Kearns et al. 1998, Kremen et al. 2002, Aizen and Feinsinger 2003, Goulson et al. 2008, Winfree et al. 2009). A deficiency in nectar and pollen resources will lead to demographic decreases in bee colonies for reasons listed above. Recognizing that species may have to survive in human modified areas if they are to survive at all necessitates work to understand how pollinators function in highly disturbed environments. Studies have shown that urban and residential areas provide suitable habitat for native bees (Frankie et al. 2005, Cane et al. 2006, Winfree et al., 2007). There is anecdotal evidence suggesting that honey bees perform well in highly developed landscapes, yet no studies have examined specifically the floral resources this species utilizes in urban environments. Elucidation of causal relationships between plant community composition and habitat characteristics may provide information useful for bee conservation, especially as it applies to urban and residential habitats (Hernandez 2009). Due to the cottage beekeeping industry, it is doubtful that honeybees will disappear from urban areas. Nonetheless, determining the flora utilized by bees in areas of high anthropogenic disturbance may reveal specific plants suitable for landscape enhancement of floral resources for other pollinators in urban, semi-natural, and agricultural ecosystems.

This study utilizes the techniques of mellissopalynology, or the study of pollen found in honey, to determine the plant taxa providing urban honey bees with pollen. Specifically, I asked (1) what is the relative colony fitness of honey bee hives located in Philadelphia, PA? (2) Is there a positive relationship between colony fitness and the diversity of pollen types (representing forging effort) found in corresponding honey samples? (3) What are the plant taxa visited by urban honey bees? I expected that the high level of disturbance present in Philadelphia would result in honey bees visiting many weedy, non-native species. Additionally, due to the positive benefits of broad diet breadth, I propose that pollen type diversity found in honey samples would be positively correlated with hive brood levels.

## METHODS

Investigation into the effects of foraging diversity on colony fitness necessitated both lab and field work. By measuring the relative amount of brood in each sample hive I calculated an index of hive reproductive potential. This measure was compared to the number of observed pollen types as determined by qualitative mellissopalynological analysis.

**Study Area.** The study site was Philadelphia County (40° 00’ N and 75° 09’ W). A city of 1,526.006 occupants, Philadelphia has an average of 11,380 persons per square mile (US Census 2011). Of the 84,420 acres that comprise the municipality, 20% (16,884 acres) are covered with tree canopy. An additional 24% of the area (20,821 acres) is designated as grass and shrub-

covered (O'Neil-Dunne 2011). Potential forage habitats fall under the five land type categories typical of urban environments as designated by Hernandez et al. (2009). Remnant or seminatural habitats, managed gardens, unmanaged weedy sites, parks, and home gardens are all common in Philadelphia. The Flora of Pennsylvania Database has collection records for 1751 species in Philadelphia County (Flora of Pennsylvania Database, May 2012).

**Brood Level Measurement.** I visited over 20 *A. mellifera* hives for brood analysis. For the purpose of this study only Langstroth hives with standard hive boxes (henceforth "supers") and frames were analyzed and therefore some hives were excluded. Super size varied among beekeepers; shallow, medium and deep frames were encountered with average area values of 80.75, 95.63, and 144.50 $in^2$ respectively. Hive area was determined as the summation of the surface area of each frame present in the hive during the sampling period. Sample hives were inspected and each frame containing brood was photographed for image analysis. Using ImageJ the total brood area of each sample hive was summarized. As a measure of hive reproductive potential, the Brood Index (BI) was determined as the *quotient of total brood area and total hive area:*

$$Brood\ Index\ (\%) = 100\left(\frac{\sum(\boldsymbol{A}\ Brood\ per\ Frame)}{(\boldsymbol{A}\ Frame \times \#\ Frames)}\right)$$

**Mellissopalynological Analysis.** Honey bees possess a crop in which nectar and pollen mix, and therefore honey is an effective sample of the bees foraging output (Roulston & Cane 2000). I collected 16 honey samples from August to November 2011. Most Philadelphia beekeepers extract honey only once a year, and these honey samples are representative of the season's yield to date. The geographic distribution of hives sampled is shown in Appendix 1.

Chemical treatment of samples adopted the methods recommended by the International Commission for Bee Botany (Louveaux et al., 1978). Five grams of honey were dissolved in 10 ml of distilled water and centrifuged (10 minutes, 7000 r/min). The resulting supernatant was discarded and the remaining residue was again diluted and centrifuged (10 minutes, 7000 r/min). After the second wash, 5 ml of acetolysis mixture (9:1 acetic anhydride to sulfuric acid 95%) was added to the residue. Samples were incubated at 70° C in a heatblock for 10 minutes. The acetolyzed pollen was again centrifuged and the supernatant was discarded. Due to high corrosivity, the residual acetolysis mixture was diluted and centrifuged again. The final residue was transferred onto 75 x 25 mm microscope slides using a Pasteur pipette and left to dry. The sample area was covered with glycerine jelly with basic fuchsin and a cover slip. The pollen present in representative honey samples was observed with a Zeiss Axioskop microscope at 400x.

Restricted time and resources did not allow for full species-level identification of pollen types observed. Nonetheless, a relative measure of foraging diversity was obtained by differentiating palynomorphs, or pollen types. Based upon the morphological classification system of Traverse (2007) palynomorphs were distinguished by their size, aperture number, aperture type (pore, sulcus, colpus), aperture ornamentation (operculum, annulus, margos), exine surface structuring (psilate, pitted, foveolate, fossulate, scabrate, gemmate, clavate, verrucate, baculate, echinate and/or regulate). For each hive a linear regression was run between the colony BI and the number of palynomorphs found in a corresponding honey sample.

## RESULTS

Hive size varied considerably ($M$ = 1,1240.69, $SD$ = 4831.11) within the 16 hives chosen for mellissopalynological analysis, with total areas ranging from 24,862.50 $in^2$ to 5,737.50 $in^2$ (Table 1). The range of measurements is the result of differing hive arrangements. Beekeeping practices within Philadelphia varied in number of hive supers, super size, and number of frames per super. Brood area varied considerably ($M$ = 469.40, $SD$ = 284.16) among the different hive arrangements (Table 1). For instance the highest brood area (*A-19148*: ca. 951 $in^2$) was recorded in a hive constructed of 4 medium size supers with 2 supers containing 9 frames each and 2 supers containing 10 frames each. The hive with the lowest brood area (*P-19144*: ca. 19 $in^2$) was recorded in a hive with 2 deep supers and 1 shallow each with 9 frames. Linear regression analysis indicated no interaction between hive size and brood amount, $r(14) = 0.04$, $p = 0.42$. In two instances (*N-19130* and *I-19103*) honey samples were extracted from two hives. Under these circumstances the hive areas were combined, in this way foraging effort and brood amount were treated as if from a single colony.

**Table 1** Comparison of hive measurements including hive area, brood area and the resulting BI for each of the 16 hives sampled across Philadelphia. The number of palynomorphs observed in corresponding honey samples is also shown.

| Hive & Zip Code | Total Hive Area ($in^2$) | Brood Area ($in^2$) | Brood Index (%) | # of palynomorphs |
|---|---|---|---|---|
| *A-19148* | 7159.00 | 951.42 | 13.29 | 53 |
| *B-19119* | 6885.00 | 836.82 | 12.15 | 49 |
| *C-19147* | 9562.50 | 784.18 | 8.20 | 32 |
| *D-19104* | 9605.00 | 605.15 | 6.30 | 54 |
| *E-19129* | 7650.00 | 475.78 | 6.22 | 46 |
| *F-19143* | 13317.00 | 814.22 | 6.11 | 73 |
| *G-19129* | 11857.50 | 592.57 | 4.99 | 50 |
| *H-19104* | 11857.50 | 491.82 | 4.15 | 68 |
| *I-19103* | 13311.000 | 541.40 | 4.07 | 78 |
| *J-19119* | 11560.00 | 384.25 | 3.32 | 46 |
| *K-19102* | 5737.50 | 154.59 | 2.69 | 55 |
| *L-19125* | 11517.50 | 241.98 | 2.10 | 70 |
| *M-19147* | 10115.00 | 148.27 | 1.47 | 78 |
| *N-19130* | 24862.50 | 274.53 | 1.10 | 40 |
| *O-19144* | 18198.50 | 178.00 | 0.98 | 57 |
| *P-19144* | 6655.50 | 19.47 | 0.29 | 67 |
| **AVERAGE** | 11240.69 | 468.40 | 4.84 | 57.25 |
| **STDEV** | 4831.11 | 284.16 | 3.82 | 13.72 |

The resulting Brood Indices offer an individually normalized measure of hive reproductive potential (Table 1). Percentage values were based on the total area of the hive, representing potential brood space, and the current level of brood during the sampling period. Accordingly, percentage values varied ($M$ = 4.84, $SD$ = 3.82). For each hive the number of palynomorphs from

a corresponding honey sample was determined ($M$ = 57.25, $SD$ = 13.72). Counts of different pollen types ranged from 78 (*I-19103* & *M-19147*) to 32 (*C-19147*) for honey samples (Table 1). Linear regression analysis revealed no significant positive correlation between hive BI and the number of palynomorphs found in a corresponding honey sample $r(14) = 0.12$, $p = 0.20$ (Figure 1). Additionally, there was no significant causal relationship between brood area and the number of observed palynomorphs $r(14) = 0.08$, $p = 0.30$.

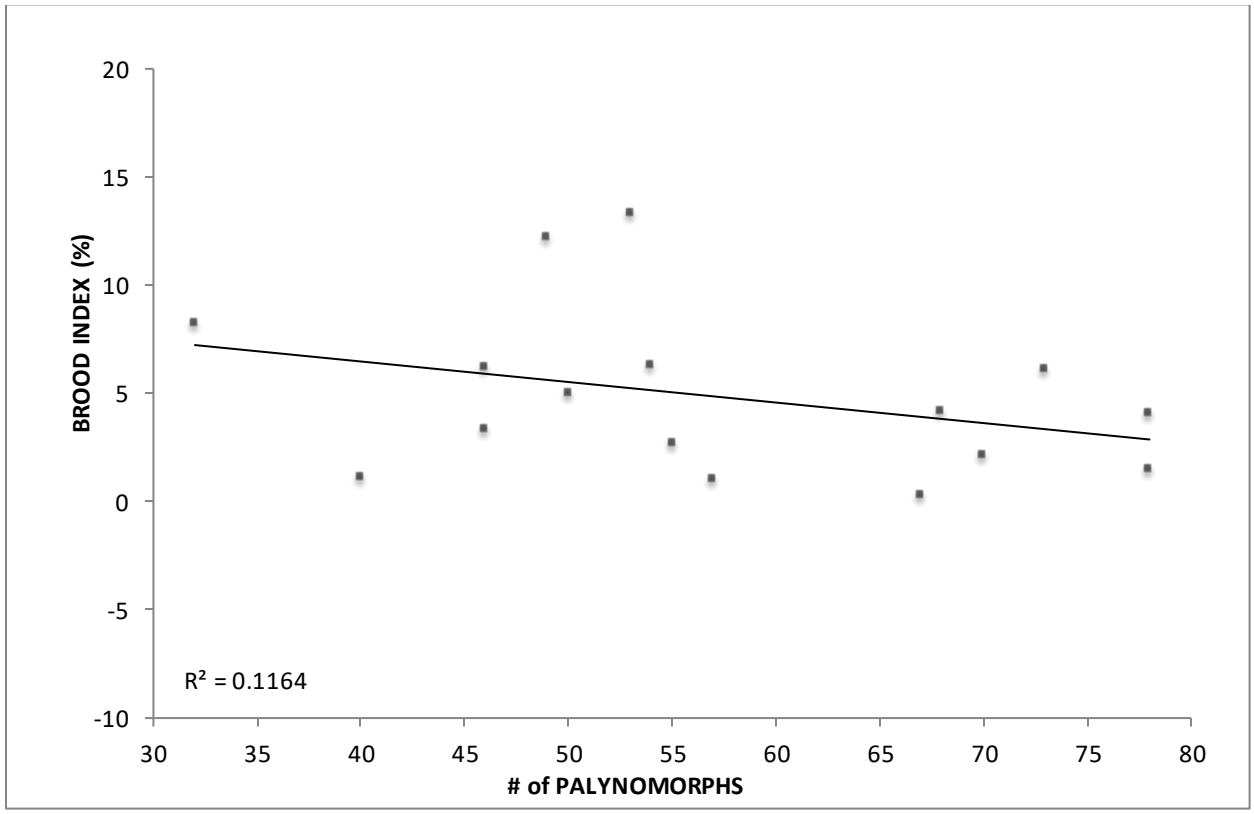


**Fig 1** Regression analysis of the influence of foraged-pollen diversity and colony fitness as measured by Brood Index.

Although few pollen types were identifiable to species, many possessed morphological characters that enabled family level identification. Cross analysis with The Flora of Pennsylvania Database revealed those locally represented species from identified families. For instance, pollen from the Vitaceae is typically radially symmetrical, 20-25 µm across and tricolporate with a faveolate or faveolate-reticulate exine. Members of the Vitaceae commonly found in Philadelphia include: *Vitis vulpine, V. riparia, V. labrusca, V. aestivalis, Parthenocissus tricuspidata, P. quinquefolia* and *Ampelopsis brevipedunculata* (Flora of Pennsylvania Database, March 2012). Pollen types from the 16 honey samples analyzed were identified to 28 families and from these families 154 candidate genera were determined (Appendix 1).

## DISCUSSION

A positive interaction between foraged-pollen diversity and honey bee colony fitness was not found (Figure 1). The nutritional benefits of polyfloral foraging could not be confirmed. Although reports show that monofloral diets can improve larval production (Tasei & Aupinel

2008), the results presented here likely suffer from faulty sampling. This is not surprising; as privately managed hives exhibit great variability. Beekeepers in Philadelphia practice a range of management techniques (I.E. pest control, supplemental feeding, colony subdivision) and the lack of a standardized hive confounded results considerably. As a metric to assess colony fitness, Brood Index proved to be methodologically successful, but its validity as an accurate representation of reproductive potential requires further study. All brood was measured during autumn months when honey bees decrease their larval output in preparation for winter. The levels reported here are thus only representative of late season colony fitness and do not accurately portray the overall health of a hive.

Similarly, mellissopalynology techniques offered a novel approach to understand pollinator visitation, yet yielded questionable results. Visually recording floral visitation does not provide an accurate measure of cumulative foraging effort; pollen analysis triumphs with its elimination of observation bias and its potential to understand foraging frequency through pollen counts. However, the use of honey as a medium to observe pollen foraging is not completely representative and pollen contamination can occur. Instances of pollen from anemophilous species such as *Pinus*, *Betula*, or *Ulmus* were observed (Appendix 1). The use of pollen traps placed at the entrance to hives is an alternative method that would provide a direct representation of pollen intake. Unfortunately, the use of privately owned hives did not allow for this.

In the present study pollen types were analyzed from honey that was extracted from hives from June to October and are therefore only representative of the foraging to date. The disjunction between honey sampling and brood sampling times affected the outcome of this study. Future palynology-based foraging studies would benefit from standardized hive setups, routine brood analysis throughout the season, and regular sampling of pollen collected via pollen traps.

Honey from Philadelphia had an average of 57.25 ± 13.72 palynomorphs per sample (Table 1); representing a higher degree of polylecty than previously reported. In Finland 116 different pollen types were analyzed from honey samples, with an average of 27.3 different pollen types per sample (Salonen et al. 2009). The broader diet breadth exhibited by urban honey bees is likely the result of proximate habitat construction. Whereas in Finland samples were collected from hives near low diversity agricultural land, pollen counts from the present study are representative of the surfeit of ruderal species typical to areas of high anthropogenic disturbance. Of the 28 families observed in this study, palynomorphs encountered frequently belonged to Fabaceae type, Brassicaceae type, Polygonaceae type, Anacardiaceae type, and Vitaceae type pollen. Also of note is the utilization of urban street trees as a floral resource; *Tilia spp.* pollen was predictably frequent among all samples. Species level identification for Fabaceae type palynomorphs was not achieved, but field observations indicate that *Gleditisia tricanthos*, *Robinia pseudoacacia* and *Styphnolobium japonicum* are utilized by honey bees and contribute pollen. Likewise, identification of Rosaceae type pollen proved challenging, but *Prunus spp.* and *Pyrus calleryana* occur commonly within Philadelphia and are probable pollen sources. Again, it should be noted that these results represent only the foraging effort of the hive to the date of honey extraction. The number of pollen types encountered would change with local floral phenology. An increase in family representation was observed in feral honey bees foraging perennially in a Texan coastal prairie plain. A total of 95 different pollen types, including 43 families, 66 genera, and 29 unknown taxa were recorded with seasonal fluctuations in pollen frequency (Baum et al. 2004). Seasonal fluctuations in floral resources are another aspect of honey bee foraging that should be analyzed through routine sampling of pollen traps.

Understanding specifically the composition of local apiflora has important implications for bee conservation. Selecting plants identified through palynological analysis to be principal pollen sources can ameliorate the problem of reconnecting plants and pollinators in ecological restoration efforts. Pollinator conservation literature stresses the importance of establishing 'framework' and 'bridging' plants (Dixon 2009, Bluthgen & Klein 2011, Menz et al. 2011). Investigation of pollen frequencies will help identify with greater specificity strong candidate 'framework' plants, while analyzing seasonal fluctuations of pollen intake will elucidate exactly the 'bridge' taxa visited during otherwise resource limited periods. Although honey bees provide only the insight of a non-native generalist, determining the extent of foraging behaviors in an urban environment demonstrates how pollinator systems continue to function in areas of high disturbance. After habitat protection, the most intuitive conservation action to improve the livelihood of pollinators is the addition and preservation of those plants shown to be floral resources. Pollen analysis coupled with field observations comprise a methodology that could indicate precisely, and without observational bias, the flora providing bees with pollen.

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# APPENDIX

**Appendix 1** Distribution of sample hives (orange hexagons) throughout Philadelphia County

| Potential Apiflora of Philadelphia County, PA | | |
|---|---|---|
| *Amaranthaceae* | | |
| | *Amaranthus spp.* | amaranth |
| | *Atriplex littoralis* | Seashore orach |
| | *Atriplex patula* | Spreading orach |
| | *Atriplex prostrata* | Halberd-leaved orach |
| | *Chenopodium spp.* | Goosefoot |
| | | |
| *Anacardiaceae* | | |
| | *Toxicodendron radicans* | Poison-ivy |
| | *Rhus typhina* | Staghorn sumac |
| | *Rhus glabra* | Smooth sumac |
| | *Rhus copallinum var. latifolia* | Shining sumac |
| | *Cotinus coggygria* | Smoke-tree |
| | | |
| *Aquifoliaceae* | | |
| | *Ilex verticillata* | Winterberry |
| | *Ilex opaca* | American holly |
| | *Ilex crenata* | Japanese Holly |
| | | |
| *Araliaceae* | | |
| | *Aralia spinosa* | Hercules'-club |
| | *Aralia racemosa* | Spikenard |
| | *Aralia nudicaulis* | Wild sarsaparilla |
| | *Aralia elata* | Japanese angelica-tree |
| | | |
| *Asteraceae* | | |
| | *Eupatorium spp.* | Eupatorium |
| | *Solidago spp.* | Goldenrod |
| | *Symphyotrichum spp.* | Aster |
| | *Taraxacum spp.* | Dandelion |
| | | |
| *Bignoniaceae* | | |
| | *Catalpa speciosa* | Northern catalpa |
| | *Catalpa bignonioides* | Southern catalpa |
| | *Campsis radicans* | Trumpet-vine |
| | | |
| *Betulaceae* | | |
| | *Betula lenta* | Black birch |
| | *Betula nigra* | River birch |
| | *Betula populifolia* | Gray birch |
| | *Betula pubescens* | Downy birch |

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|---|---|---|
| | *Carpinus caroliniana* | Hornbeam |
| | | |
| *Brassicaceae* | | |
| | *Brassica juncea* | Brown mustard |
| | *Brassica nigra* | Black mustard |
| | *Brassica rapa* | Field mustard |
| | *Cardamine spp.* | Bittercress |
| | *Lepidium spp.* | Cress |
| | *Rorippa palustris* | Marsh watercress |
| | *Rorippa sylvestris* | Creeping yellowcress |
| | *Sinapis alba* | White-mustard |
| | *Sinapis arvensis* | Charlock |
| | *Thlaspi arvense* | Field pennycress |
| | | |
| *Celastraceae* | | |
| | *Celastrus orbiculatus* | Oriental bittersweet |
| | *Celastrus scandens* | American bittersweet |
| | *Euonymus alatus* | Winged euonymous |
| | *Euonymus americanus* | Hearts-a-bursting |
| | *Euonymus atropurpureus* | Burning-bush |
| | *Euonymus europaeus* | European spindletree |
| | *Euonymus fortunei* | Wintercreeper |
| *Caprifoliaceae* | | |
| | *Lonicera tatarica* | Tartarian honeysuckle |
| | *Lonicera standishii* | Honeysuckle |
| | *Lonicera sempervirens* | Trumpet honeysuckle |
| | *Lonicera morrowii* | Morrow's honeysuckle |
| | *Lonicera japonica* | Japanese honeysuckle |
| | | |
| *Cornaceae* | | |
| | *Cornus racemosa* | Gray dogwood |
| | *Cornus florida* | Flowering dogwood |
| | *Cornus amomum ssp. obliqua* | Oblique Silky dogwood |
| | *Cornus amomum ssp. amomum* | Silky dogwood |
| | *Cornus alternifolia* | Alternate-leaved dogwood |
| | | |
| *Adoxaceae* | | |
| | *Sambucus canadensis* | American elder |
| | | |
| *Fabaceae* | | |
| | *Amorpha fruticosa* | False-indigo |
| | *Gleditsia triacanthos* | Honey-locust |
| | *Medicago lupulina* | Black medic |
| | *Medicago sativa* | Alfalfa |

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|---|---|---|
| | *Melilotus albus* | White sweet-clover |
| | *Melilotus officinalis* | Yellow sweet-clover |
| | *Robinia hispida* | Bristly locust |
| | *Robinia pseudoacacia* | Black locust |
| | *Robinia viscosa* | Clammy locust |
| | *Styphnolobium japonicum* | Japanese pagoda-tree |
| | *Trifolium arvense* | Rabbit's-foot clover |
| | *Trifolium aureum* | Large yellow hop-clover |
| | *Trifolium campestre* | Low hop-clover |
| | *Trifolium hybridum* | Alsike clover |
| | *Trifolium incarnatum* | Crimson clover |
| | *Trifolium pratense* | Red clover |
| | *Trifolium reflexum* | Buffalo clover |
| | *Trifolium repens* | White clover |
| | *Vicia americana* | Purple vetch |
| | *Vicia hirsuta* | Vetch |
| | *Vicia sativa ssp. nigra* | Black garden vetch |
| | *Vicia sativa ssp. sativa* | Garden vetch |
| | *Vicia tetrasperma* | Slender vetch |
| | *Vicia villosa ssp. varia* | Winter vetch |
| | *Vicia villosa ssp. villosa* | Vicia villosa ssp. villosa |
| | *Wisteria floribunda* | Japanese wisteria |
| | *Wisteria frutescens* | American wisteria |
| | *Wisteria sinensis* | Chinese wisteria |
| | | |
| *Lamiaceae* | | |
| | *Glechoma hederacea* | Gill-over-the-ground |
| | *Lamium amplexicaule* | Henbit |
| | *Lamium purpureum* | Purple dead-nettle |
| | *Lycopus americanus* | Water-horehound |
| | *Lycopus europaeus* | European water-horehound |
| | *Lycopus rubellus* | Gypsy-wort |
| | *Lycopus uniflorus* | Northern bugleweed |
| | *Lycopus virginicus* | Virginia water horehound |
| | *Prunella vulgaris ssp. lanceolata* | Lance selfheal |
| | *Prunella vulgaris ssp. vulgaris* | Common selfheal |
| | | |
| *Lythraceae* | | |
| | *Lythrum alatum* | Winged loosestrife |
| | *Lythrum hyssopifolia* | Hyssop loosestrife |
| | *Lythrum salicaria* | Purple loosestrife |
| | | |
| *Malvaceae* | | |
| | *Tilia americana var. americana* | Basswood |

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|---|---|---|
| | *Tilia americana var. heterophylla* | White basswood |
| *Paulowniaceae* | | |
| | *Paulownia tomentosa* | Empress-tree |
| *Phytolaccaceae* | | |
| | *Phytolacca americana* | Pokeweed |
| *Plantaginaceae* | | |
| *Polygonaceae* | | |
| | *Fallopia convolvulus* | Black bindweed |
| | *Fallopia japonica* | Japanese knotweed |
| | *Fallopia sachalinensis* | Giant knotweed |
| | *Fallopia scandens* | Climbing false-buckwheat |
| | *Persicaria spp.* | Smartweed |
| | *Polygonum aviculare* | prostrate knotweed |
| | *Polygonum aviculare* | Knotweed |
| | *Polygonum aviculare* | Doorweed |
| | *Polygonum erectum* | Erect knotweed |
| | *Polygonum ramosissimum ssp. ramosissimum* | Bushy knotweed |
| | *Polygonum tenue* | Slender knotweed |
| | *Rumex spp.* | Dock |
| *Rhmanaceae* | | |
| | *Rhamnus cathartica* | Common buckthorn |
| | *Rhamnus frangula* | Alder buckthorn |
| | *Ceanothus americanus* | New Jersey tea |
| | *Rhamnus cathartica* | Common buckthorn |
| | *Rhamnus frangula* | Alder buckthorn |
| *Rosaceae* | | |
| | *Photinia parviflora* | Photinia |
| | *Photinia pyrifolia* | Red chokeberry |
| | *Photinia villosa* | Oriental photinia |
| | *Potentilla spp.* | Cinquefoil |
| | *Prunus americana* | Wild plum |
| | *Prunus avium* | Sweet cherry |
| | *Prunus cerasus* | Pie cherry |
| | *Prunus mahaleb* | Mahaleb cherry |
| | *Prunus padus* | European bird cherry |
| | *Prunus persica* | Peach |
| | *Prunus serotina* | Wild black cherry |
| | *Prunus subhirtella* | Higan cherry |

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|---|---|---|
| | *Prunus virginiana* | Choke cherry |
| | *Pyrus calleryana* | Callery pear |
| | *Rubus spp.* | |
| | | |
| *Sapindaceae* | | |
| | *Acer rubrum* | Red maple |
| | *Koelreuteria paniculata* | Golden rain-tree |
| | | |
| *Scrophulariaceae* | | |
| | *Verbascum blattaria* | Moth mullein |
| | *Verbascum lychnitis* | White mullein |
| | *Verbascum phlomoides* | Orange mullein |
| | *Verbascum sinuatum* | Wavyleaf mullein |
| | *Verbascum thapsus* | Common mullein |
| | | |
| *Simaroubaceae* | | |
| | *Ailanthus altissima* | Tree-of-heaven |
| | | |
| *Ulmaceae* | | |
| | *Ulmus americana* | American elm |
| | *Ulmus parvifolia* | Chinese elm |
| | *Ulmus pumila* | Siberian elm |
| | *Ulmus rubra* | Red elm |
| | | |
| *Verbenaceae* | | |
| | *Verbena spp.* | Vervain |
| | | |
| *Vitaceae* | | |
| | *Ampelopsis brevipedunculata* | Porcelain-berry |
| | *Parthenocissus quinquefolia* | Virginia-creeper |
| | *Parthenocissus tricuspidata* | Boston ivy |
| | *Vitis aestivalis* | Summer grape |
| | *Vitis labrusca* | Fox grape |
| | *Vitis riparia* | Riverbank grape |
| | *Vitis vulpina* | Frost grape |